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Forest Service Research Highlights

United States Department of Agriculture
Forest Service
FS-519

To accomplish its mission of providing leadership in forestry, the Forest Service in the United States Department of Agriculture maintains the world's largest forest research organization. Its members include 715 full-time scientists and many cooperators in other public agencies, universities, environmental organizations, and industry. Their purpose is to discover and disseminate the scientific information needed to protect, manage, and appropriately enjoy public and private forests in the United States and throughout the world.

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The mission of Forest Service Research is to serve society by developing and communicating the scientific information and technology needed to protect, manage, use, and sustain the natural resources of forest and range lands for the benefit of all the people of the United States. Research in the Forest Service is also directed toward expanding the knowledge base on environmental issues of major public concern.

This publication (and others that we plan to issue in succeeding years) highlights examples of outstanding research accomplishments by the Forest Service's research scientists in 1991. Specific results are documented in over 2,400 articles published in the scientific literature. Rather than treating the findings of individual studies as separate events, we describe them under the following nine headings:

- Forest pests
- Biotechnology
- Ecology and biodiversity
- Wetlands and water quality
- Global change
- Tropical forestry
- Recreation and urban forestry
- Wood and its products
- Recycling

Cover Photos: AA-2636, Left Inset- AA-2637, Right Inset- AA-2638, Lower Inset- AA-2639; Inside Cover-AA-2640

Forest Pests

Insects and disease organisms have been attacking trees for as long as trees have existed. Foresters know that what we humans think of as "attacks" insects regard as "meals." They know that insects are important components of forest ecosystems and they do not begrudge meals to a few insects. But they become concerned when millions of insects of a given species are eating, reproducing in, and killing large numbers of trees. Then the system is out of balance and some corrective action becomes necessary. The trick is to reduce the insect population with minimum disturbance to the ecosystem.

Bark beetles create that kind of problem. Periodically, southern pine beetle populations "explode," and when they do they may kill every pine in areas ranging from less than an acre up to hundreds of acres. Southern Station entomologists have been working with the Texas Forest Service to explain why populations of these beetles fluctuate so widely. They cause catastrophic damage in some years and next to none in others. Weather patterns like prolonged droughts and warm winters are often blamed, but no one has had much success in predicting beetle outbreaks from weather observations. Scientists have comprehensively analyzed 30 years of weather and bark beetle population data in east Texas, where the climate is nearly ideal for southern pine beetles. They have concluded that changes in beetle populations are controlled by mechanisms that respond slowly to increases in beetle numbers. The numbers of natural regulators, such as predators and parasites, do not increase immediately when the beetle population grows and do not decline immediately when it starts to decline. As a result, beetle numbers fluctuate very widely. In east Texas, beetle numbers peak about once every 8 years. For those hoping to forecast beetle outbreaks, weather cannot be ignored, but the best predictors may be the current population size and the timing of the last outbreak.

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In related research on southern pine beetle behavior, Southern Station researchers measured dispersal patterns of beetles that had been marked with fluorescent dust and attracted to pheromone-baited traps. (Pheromones are chemicals produced by insects that influence the behavior of other members of their species.) The scientists found that half the marked beetles released in an area flew at least 0.4 mile to reach the traps. These results are important in evaluating the risks to large areas of forest if large concentrations of beetles are controlled by disrupting insect behavior with pheromones.

Drought-related beetle infestations have exploded in western forests. Environmentally safe alternatives to toxic pesticides are being developed by entomologists in the Pacific Southwest and Pacific Northwest Stations. Early research results are promising. Aerially applied verbenone, an anti-aggregation pheromone, held beetle populations down in lodgepole pine stands to about one-fourth the level detected in untreated control plots. Anti-aggregation pheromones cause insect dispersion rather than aggregation. In a sense, the chemical sends a "no vacancy" message to the beetle and can be used to help protect high-quality timber and recreational sites from damaging infestations.

Insects are a big threat to forest health, but so are other organisms, such as fungi (fusiform rust), bacteria, nematodes, and parasitic seed plants (mistletoes). These last organisms get their nutrients from trees and some are more injurious than others.

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Fusiform rust is the most serious disease affecting young loblolly and slash pine plantations. The disease causes galls on tree boles and limbs. Some trees with stem galls die quickly, while others can survive and grow for many years. Southeastern Station scientists have developed methods for predicting which slash and loblolly pines will die from the disease and when. Their findings have been translated into guidelines for thinning infected plantations.

Dwarf mistletoes, a group of plants related to the Christmas mistletoe, parasitize North American pines, spruces, and firs. They can kill, deform, or reduce the growth of infected trees, causing serious forest damage over large areas. Since the mid-1950's,

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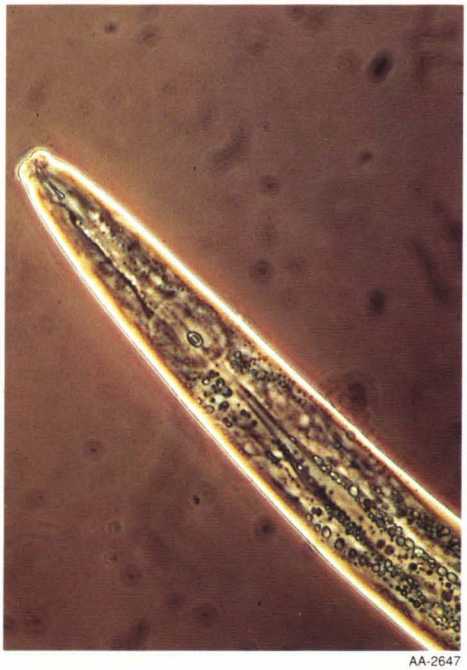
pathologists at the Rocky Mountain Station have been studying the biology and control of mistletoes. As a result, there are now economical and environmentally acceptable methods for controlling dwarf mistletoes in many forest situations. Because mistletoes are host-specific—each species or strain attacks only one species of tree—control often depends on cutting heavily infested stands and planting another species of tree. To provide more options for forest managers, researchers now are trying to locate and breed trees that are resistant to dwarf mistletoe.

The **pine wood nematode** is a microscopic "worm" that feeds on living cells of pine trees. It is common in North America but causes little or no damage here. However, this same worm causes a serious wilt disease of pines in Japan. In order to minimize the chances of introducing this pest to Europe, members of the European Economic Community have been considering a kiln-drying requirement for all softwood lumber imported from North America. A Southeastern Station pathologist has shown that pine wood nematodes in southern pine lumber are killed very rapidly by heating the lumber. Considerably less time and heat are required for killing nematodes than for kiln drying. Nematode-free lumber can thus be produced rather easily by North American manufacturers without actually having to kiln-dry the lumber.



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Biotechnology

Advances in biotechnology offer much hope for solving forestry problems. In managing forest pests, for example, foresters must use treatments that are cheap, effective, and nonpolluting. Thus, in forests, biological control agents are better choices than chemical pesticides.

The **gypsy moth**, long a serious pest of hardwood forests in the Northeast, is spreading into the Southeast and Midwest and a new strain, the Asian gypsy moth, has landed in the Pacific Northwest. A nuclear polyhedrosis virus (NPV) can infect and kill gypsy moths with little to no environmental impact. When it is sprayed on an area, it kills moth caterpillars in large numbers. So far, however, it has proven more expensive and less effective than other control agents.

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Northeastern Station scientists have been working to develop highly potent strains of NPV to combat the gypsy moth. Strains differ in their ability to infect and kill the moths, and scientists have refined a technique for marking and recognizing improved strains. In a neat bit of genetic engineering, they added a marker, a beta-galactosidase gene, to the genetic material of the viral strain they are working with. Later generations of the virus that contain that material can then be easily identified with a colorimetric test.

In addition to combating pests, products of biotechnology can be used to improve products made from wood. In paper manufacturing, wood fibers must be separated from one another by mechanical or chemical means. Mechanical separation is energy intensive and weakens wood fibers, reducing the strength of the paper. Chemical separation techniques make stronger paper, but they reduce yields and create difficult wastewater problems.

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Scientists at the Forest Products Laboratory are exploring a new approach—biomechanical pulping—in which wood chips are softened by exposing them to the same fungi that cause white rot in trees and then pulped mechanically. The

promising results have led to the formation of a consortium to develop the technology; members include the Forest Products Laboratory, the University of Wisconsin, and 21 companies in the pulp and paper industry. The consortium's research has produced two patents so far.

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Wood-decay fungi also are showing considerable promise for degrading toxic chemicals in contaminated soil. In cooperation with the Environmental Protection Agency, scientists at the Forest Products Laboratory have shown that two white-rot fungi are capable of reducing pentachlorophenol concentrations in contaminated soil by 90 percent. By controlling soil moisture and temperature to favor fungal growth, they think they can accelerate the breakdown of pentachlorophenol to nontoxic products.

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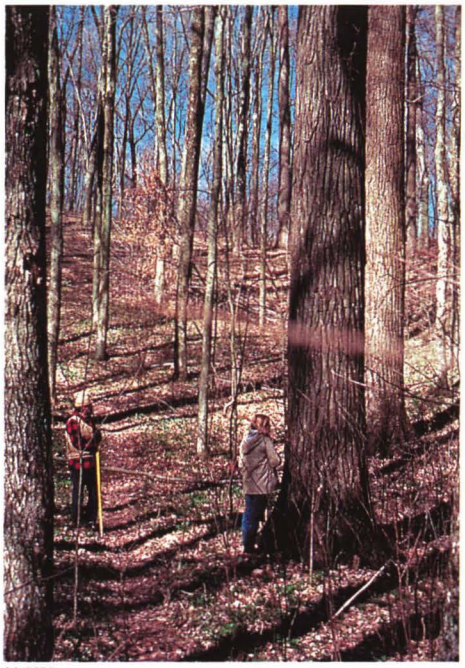
Ecology and Biodiversity

The National Forest Management Act requires maintenance and enhancement of biological diversity on national forests. The basis for the requirement is easy to understand. The public is concerned about species extinctions, and habitats for some species are becoming increasingly rare on private land in the United States. The methods for maintaining and enhancing biological diversity are much less obvious, and forest managers are depending heavily on research scientists for appropriate direction.



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At the North Central Station, researchers have developed a set of recommendations for maintaining and enhancing biological diversity on land under multiple-use management. The recommendations help managers to concentrate on the elements of diversity that are most at risk. As a result, the Shawnee National Forest has been able to restore once-common landscape elements that were becoming rare. The Wayne-Hoosier National Forest can now consider the biodiversity of adjacent non-Federal lands in its forest planning, and the Huron-Manistee National Forest has identified a network of 173,000 acres of old-growth forests.

In the Midwest, populations of **neotropical migratory birds** requiring forest interiors for nesting habitat have been declining. These birds winter in the Central American Tropics but migrate to North American temperate zones to reproduce. Some ornithologists and other observers have theorized that clearcutting in North America is responsible for these population declines. North Central Station scientists have concluded that clearcutting may be responsible for reduced populations of some species of neotropical migrants that depend on mature forests, but not to such an extent that populations would be threatened.

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While clearcutting adversely affects some bird species, it benefits others. The scientists conclude that, in extensively forested areas like the Ozark Mountains in Missouri, clearcuts can be designed so that populations of migratory birds species requiring forest interior habitats will not be adversely affected.

Intermountain Station researchers, in partnership with the Shrub Research Consortium, have compiled information to help land managers restore biological diversity and improve range condition on over 100 million acres of grassland in the interior West. **Cheatgrass invasion** follows after shrub die-off and is intensified by periodic fires. The frequent fires eliminate many native plants and animals, reducing biological diversity.

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Cooperating with universities, the Utah Division of Wildlife Resources, the Idaho Fish and game Department, and the Bureau of Land Management, Intermountain Station scientists have found ways to break the 3- to 5-year fire cycle and have made them available in a technical report. When fire frequency is returned to its historic cycle of 30 to 72 years, native perennial grasses will replace annuals and thus improve range conditions for livestock and wildlife. Natural biodiversity will be restored, and valuable browse will be provided for big game.

The **California spotted owl** is closely related to the endangered northern spotted owl. Maintenance of healthy populations of this latter species has strongly affected management of Federal forests in much of the Pacific Northwest. Interest in the California spotted owl, therefore, runs high. Pacific Southwest Station researchers have been observing habitat needs and developing guidelines for managing forest habitats that contain California spotted owls.

In the southern Sierra Nevada, the owls occupy a variety of habitats ranging from oak woodlands at elevations as low as 1,000 feet to mixed-conifer and red fir forests as high as 8,000 feet. Summer home ranges of resident pairs average about 600 acres in oak woodlands and about 3,600 acres in mixed-conifer stands. Owl diets in oak woodlands are primarily woodrats and in the higher elevation conifer forests, primarily flying squirrels, gophers, and deer mice. In all utilized habitat types, the owls strongly prefer a dense canopy for roosting and nesting.

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Wetlands and Water Quality

People expect to find water of the highest quality in forest streams. Their concern is not only with getting pure water for human consumption downstream but also with providing habitats for fish and wildlife. In part because of the research findings at Forest Service experiment stations around the country, the quality of water coming from most national forests is excellent.

Since the 1930's, Forest Service scientists have been measuring the effects of logging and other forest treatments on water quality. From the standpoint of fish habitat, the amount of sediment in streams is a key variable, and it has been measured with great care over long periods on experimental watersheds. Researchers at the Pacific Southwest Station have developed improved methods for sampling field water quality. They have used modern computer technology to increase the reliability of estimates of stream sedimentation rates and to predict the long-term consequences of forest treatments on erosion, water quality, and fish habitat.

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In **bottomlands and wetlands**, reforestation of former agricultural land is one of the first steps in restoring the natural ecological and hydrological functions. Most experience with reforestation in the United States has been with conifers on uplands. Southern Station scientists in Mississippi, however, have learned a great deal about hardwood regeneration in lowlands. They have published guidelines for planting hardwood seedlings of many species and for directly seeding oaks and other nut-producing species. Although the guidelines were developed for the lower Mississippi Valley, the techniques are applicable over a much wider area. Their use can assure establishment of productive timber stands and valuable wildlife habitats in bottomlands and wetlands.

In the northern Great Plains, woody draws and stands of trees along permanent and intermittent streams once provided extremely rich habitats for wildlife. Grazing and fire control, however, allowed undesirable species to invade and replace fire-adapted species such as bur oak and chokecherry.

Rocky Mountain Station range scientists have developed techniques for prescribed burning to restore the original vegetation to these **riparian habitats**. Land managers in the Forest Service and the National Park Service are applying these new burning techniques. As a result, desirable woody species are being favored in habitats that are crucial for wildlife in the Great Plains.

A major gold discovery between Yellowstone National Park and the Absaroka-Beartooth Wilderness Area in the Shoshone National Forest concerns resource managers, for the area is in an ecologically sensitive alpine zone, within a grizzly bear recovery area. In addition, **exposed mine tailings** are already weathering and producing acidic materials and toxic metals that contaminate streams flowing into both the park and the wilderness. Many worry that more mining will devastate aquatic ecosystems for miles downstream.

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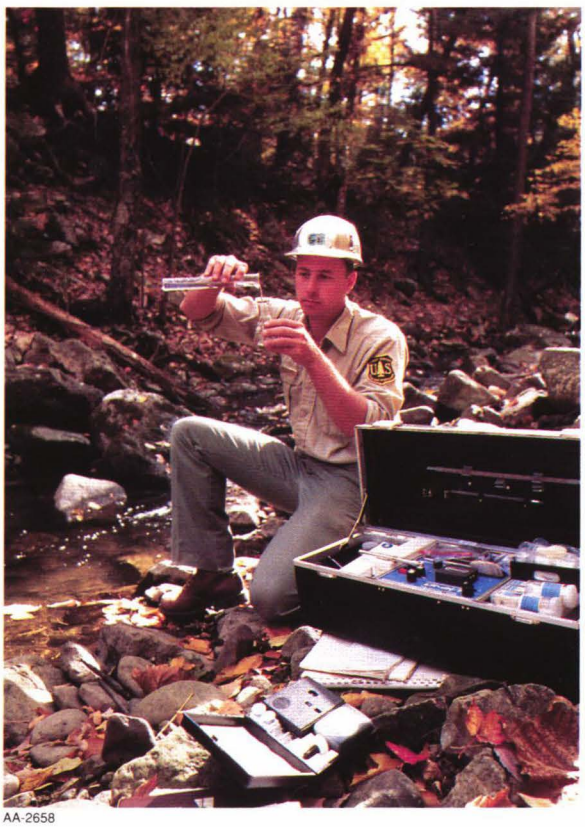
Intermountain Station scientists found ways to assess the potential impact of acid mine drainage on water quality. The scientists completed research that was critical to the preparation of a satisfactory reclamation plan that will help to protect water quality. They developed techniques and identified plants for restoring disturbed ecosystems in extreme environments like that of their high-elevation study site. In related applications, their new technology is being used to restore disturbed areas around alpine lakes in wilderness areas and above the timberline at developed ski areas.



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Global Change

As the **carbon dioxide content of the atmosphere** is increased by the burning of fossil fuels, many scientists expect the Earth's climate to warm. There is wide disagreement about the magnitude of the temperature increase and the effects it will have on climate. To some, a rise seems probable because carbon dioxide is a "greenhouse gas," that is, it permits sunlight to pass readily but restricts the return flow of heat outward. Because much of the Sun's light is converted to heat energy when it strikes the Earth's surface, a high concentration of carbon dioxide in the atmosphere may create a heat-trapping "greenhouse effect."

Forest trees are involved in this situation in two ways: first, through photosynthesis, the biochemical process by which trees use carbon dioxide from the atmosphere to make sugars, which contain carbon and are the basic building blocks of wood. Second, like other plants, trees are sensitive to changes in climate. For these reasons, Forest Service scientists have joined others in a major research effort to understand global warming and its probable effects on the health of forest ecosystems.

Prediction of probable effects of climate changes on forests requires what scientists call a "process-oriented" approach, using models that reflect current understanding of how ecosystems function.

Working at the Rocky Mountain Station, a visiting scientist from Bulgaria developed a **mathematical model** that relates tree growth, competition, and succession to the basic canopy processes of photosynthesis and transpiration. In the model, tree growth depends upon solar radiation, carbon dioxide content of the air, climatic conditions, soil water, and soil fertility. The model also examines interactions among individual trees to predict ecosystem dynamics.

Similarly, Southeastern Station scientists have developed a model that relates plant growth in forest stands to environmental conditions. That model relies upon measurement of stand-level processes such as leaf area dynamics, respiration, and photosynthesis, providing a method to assess the effects of altered climate or carbon dioxide concentration on forest productivity.

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Although concerns about ozone and other atmospheric chemicals are receiving increasing attention, interest in acid rain and its effects has not disappeared. North Central Station scientists have shown that high sulfate deposition adversely affects the growth of jack pines and red pines. They conclude that foresters should be cautious about planting those species in areas of high sulfate deposition such as southeastern Michigan.

Tropical Forestry

Environmentalists have two reasons for worrying about the disappearance of tropical rainforests. First, when an ancient rainforest is destroyed, large numbers of species are lost. Second, the loss of photosynthesis from these forests is expected to speed global warming. These concerns have led to expansions in Forest Service programs for tropical forestry research and technical assistance.

Agency research in the field is concentrated at the Southern Station's Institute of Tropical Forestry in Puerto Rico and the Pacific Southwest Station's Institute of Pacific Islands Forestry in Hawaii. Some recent findings from these institutes are encouraging.

In Puerto Rico, successive **forest inventories** show that the forested area on the island increased by 11 percent between 1980 and 1985. Considering the high population density of the island, this increase is impressive. The performance of secondary tropical forests—those that develop after an ancient forest is removed—was even more impressive. Over the same 5-year period, the increase in timber volume was 36 percent. This increase refutes the commonly held perception that secondary forests are unproductive. Secondary forests make up about half of the Earth's tropical forests. Thus, the possibility of high productivity brightens prospects of timber resources for tropical residents, particularly those in Central and South America.

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A Pacific Southwest Station scientist helped to design and plan a reserve system for the **mangrove forests** of Pohnpei, one of the four island states in the Federated States of Micronesia. Mangrove forests occur on and near the shorelines of islands, where most of the people and roads are concentrated. The land, therefore, is sought for development, and the forests are heavily exploited for timber and game. The plan for mangrove reserves, which was developed in consultation with residents and local authorities, includes preservation, production, and park areas.

The criteria for designation of reserves included presence of endangered, threatened, or rare species; presence of particularly rich biota and undisturbed old-growth communities; the need to protect biotic resources such as fisheries from excessive sediments and wave action; the need to protect cultural and economic resources; presence of highly productive forests or fisheries; and proximity to roads, waterways, and wood-consuming industries. Working closely with the Pohnpei State Division of Forestry, USDA Forest Service employees intensively inventoried the mangrove forests and estimated demands for timber and conversion of forests to other land uses. The system of mangrove reserves should do much to conserve the vital forest resources of Pohnpei.

Recreation and Urban Forestry

A region's forests contribute much to the lifestyle of its residents and to tourists and recreators. Groups of trees in and near cities provide similar benefits. Traditionally, however, economists have either ignored or undervalued these kinds of forest benefits because they are difficult to measure. Recently, Forest Service scientists have developed methods for leveling the analytical playing field.

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Researchers from the Southeastern Station and the University of Georgia have developed reliable methods for measuring the **economic benefits of recreation to local economies**. Using these methods, they demonstrated that it made good economic sense for the Tennessee Valley Authority to keep its lake levels high during the summer recreation season, even if production of hydroelectric power is reduced. The dams were originally constructed to enhance local economies through flood control and electric power generation. After flood control needs were met, lake levels were generally determined through economic analysis. Until now, however, recreation benefits were not fully considered in the analysis. Delaying late-summer drawdown for 1 month was shown to yield over $12 million in additional household and business income in the region. The results convinced the Tennessee Valley Authority that it is wise to keep lake levels higher in the summer.

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Most Americans think of planted **windbreaks** as soil conservation structures and amenities for rural areas in the Great Plains. Researchers from the Northeastern Station and the Department of Energy have shown that windbreaks have wide potential application as energy savers in urban as well as rural settings.

The scientists developed a computer program that estimates the components of energy use in buildings during each hour throughout the year. Estimates of energy savings were made for nine cities, assuming 40-foot-tall windbreaks on the north and west sides of houses. The reduction in home heating cost was estimated at 19 percent for the northernmost city in the study—Minot, North Dakota. Plantings of deciduous species on the south sides of houses in warm climates can also significantly reduce summer cooling costs. Existing trees around houses in the United States save an estimated $2 billion in energy costs each year. Good tree management could increase those savings markedly.

North Central Station scientists have developed a **computer mapping system** to display the visual characteristics of planned urban developments. The value of the program was demonstrated in Cincinnati, Ohio, where it helped managers to incorporate public preferences for visual quality into development decisions for the city's hillsides.

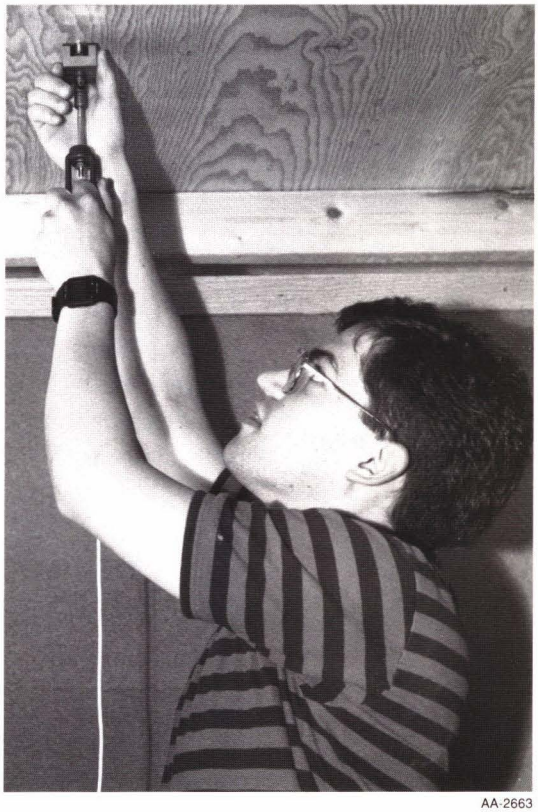
Urban developers try to build attractive communities, because a good visual impression helps to sell houses. Traditionally, however, they have not had a mechanism for including public preferences in their design decisions. In addition, individual developers have varied widely in their concepts of visual quality and in their success in achieving it. The computer mapping approach provides guidelines for developing an area while protecting its visual quality. The Cincinnati project is a prototype for other communities.

Wood and Its Products

The public is more concerned about environmental protection than ever before, and many of these concerns focus on forest ecosystems. At the same time, our society continues to demand products from forests. By improving techniques for selective harvest and manipulation of vegetation, Forest Service research is leading the way in developing profitable environmentally sensitive methods of timber harvest and transport.

Another approach to providing products while protecting forest environments is through improvements in wood products and in the utilization of existing timber supplies. Much of the Forest Service research on forest products is designed to achieve those improvements.

Composite materials consisting of wood fibers and plastics offer much promise for a wide variety of purposes. Thus far, however, these composites have been disappointingly weak because of poor adhesion between the wood fiber and the plastic. Researchers at the Southern Station have developed a new technique for analyzing the chemical structure of wood fiber surfaces, where the bonding must take place. The technique, known as inverse gas chromatography, is helping the scientists to see how differences in chemical structure affect the physical properties of wood fiber surfaces. They now are seeking ways to chemically modify fiber surfaces to increase the strength of composites.



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For many years, wood has been treated with chemical preservatives to extend its service life. Sometimes wood is treated with fire-retardant chemicals to prevent fire spread. Until recently, however, a piece of wood could not be treated with both.

Now scientists at the Forest Products Laboratory have developed a **one-step preservative and fire-retardant treatment** for use on wood. It is especially recommended for treating wooden shakes and shingles. The chemicals are nontoxic and form a polymer network in the wood as they dry. The treatment was originally developed because of declining supplies of western redcedar, the only naturally durable timber species recognized by building codes. Now, treated shakes and shingles made from other woods can be used in applications that once required western redcedar.

Supplies of hardwood timber are abundant in most of the East, South, and Midwest. Select lumber for fine furniture and cabinets, however, is not nearly as abundant. To make best use of the material that is available, Northeastern Station scientists have

developed a **computer-based simulator**. It helps mill managers to select the sawing pattern that will get the most high-quality furniture pieces from hardwood lumber of relatively low quality.

When architects and engineers are designing wooden structures, they need to know the strength of the individual wood members. Because many species and grades are available, they need to know strength properties by species and grade. Before they can specify its use, they must know, for example, how strong a grade 2 southern pine 2 by 4 is likely to be.

Design values for structural lumber were originally observed in the 1920's. At that time, most lumber was clear material from old-growth stands. Now, most structural lumber comes from second-growth stands. Technical representatives of the lumber industry, faculty members from several major universities, and scientists from the Forest Products Laboratory have just completed a 14-year project to provide reliable design values for current structural lumber. Results from this project will help in the design of buildings in the United States and in the export of U.S. lumber to Europe.

Large knots greatly reduce the strength and value of structural lumber. Forest managers can reduce the size of knots in trees by maintaining high stand densities when the trees are young. Researchers at the Pacific Northwest Station have shown that maintaining high densities in second-growth stands of Douglas-fir increases the grade of lumber produced. Based upon machine and visual lumber grades, timber grown in open stands was worth 40 percent less than timber grown in open stands.

Recycling

In part because everyone wants landfills to be in someone else's neighborhood, America is running out of places to bury its trash. The paper industry is justifiably proud of its efforts to increase use of recycled material, but even when its plans are fully implemented wood fiber in various forms will still account for most of the space in landfills.

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Scientists at the Forest Products Laboratory are looking for profitable ways to use this material as well as commonly discarded plastics. They have developed a promising product made from waste paper, polyester or polypropylene, and phenolic resins (also a wood product). This low-density fiber mat has a variety of potential uses—it is a satisfactory sheathing material and might be used for truckliners, paneling for the interiors of car doors, and soundboards for pianos.

Another innovative use of wood wastes was pioneered by the North Central Station. Researchers there mixed recycled wood fibers with Portland cement to produce lightweight concrete products, called **Chunkrete**. The wood fibers serve as a substitute for the gravel in concrete. This material is much lighter in weight than concrete and it can be fastened with screws or nails. It is considerably more resistant to fire and decay than solid wood. In addition, it can be made water resistant for outdoor applications.

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Additional Information

None of the research findings included here are described in detail. More information on individual studies may be obtained from the experiment stations where the research was conducted. The Forest Service maintains eight regional experiment stations, which are responsible for research in assigned territories, and the Forest Products Laboratory in Madison, Wisconsin (figure 1). Each discovery described here is attributed to a specific experiment station. To obtain additional information, please write to that station at the following addresses:

Intermountain Experiment Station
Federal Building
324 25th Street
Ogden, UT 84401

North Central Forest Experiment Station
1992 Folwell Avenue
St. Paul, MN 55108

Northeastern Forest Experiment Station
5 Radnor Corporate Center
100 Matsonford Road, Suite 200
PO Box 6775
Radnor, PA 19087

Pacific Northwest Forest and Range Experiment Station
PO Box 3890
Portland, OR 97208

Pacific Southwest Forest and Range Experiment Station
PO Box 245
Berkeley, CA 94710

Rocky Mountain Forest and Range Experiment Station
240 West Prospect Road
Fort Collins, CO 80526

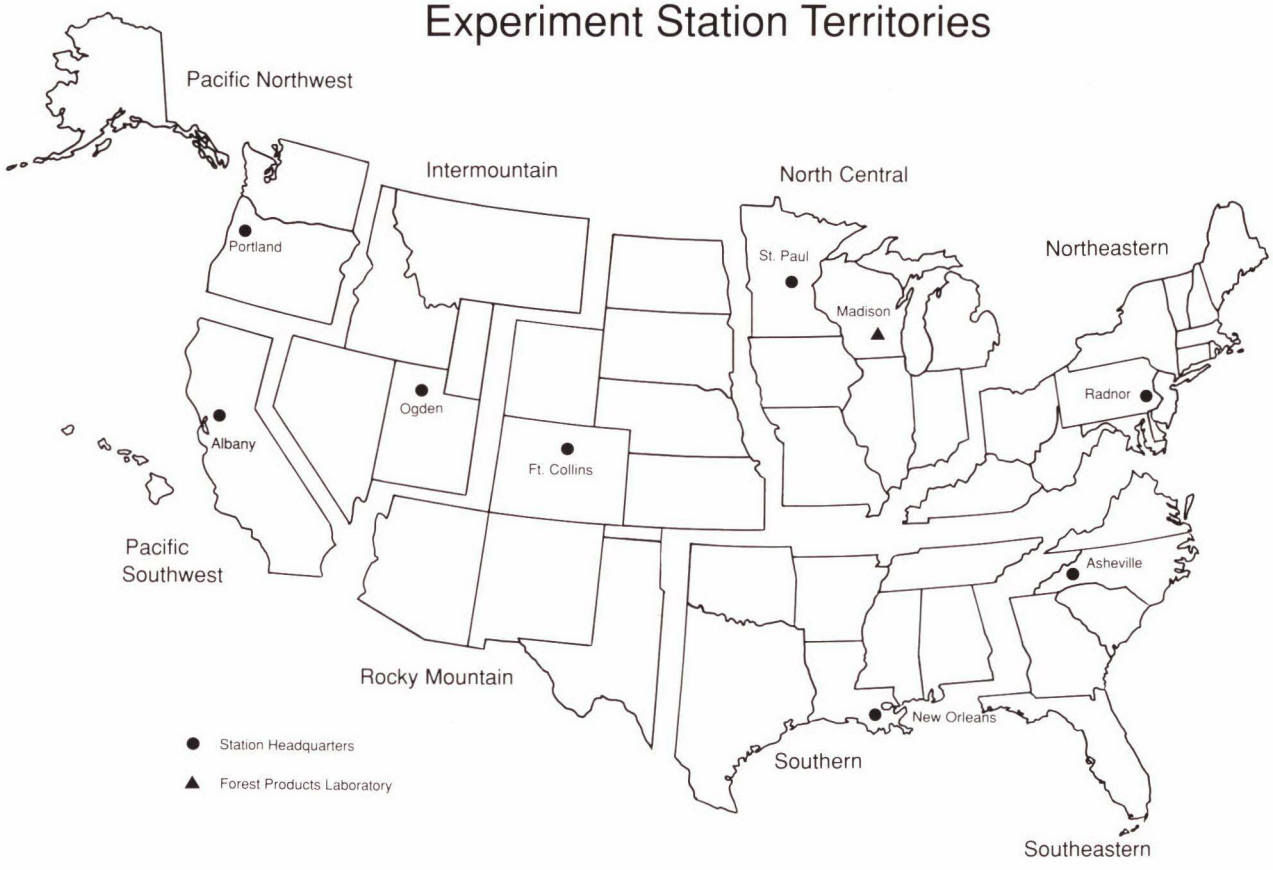
Southeastern Forest Experiment Station
200 Weaver Boulevard
PO Box 2680
Asheville, NC 28802

Southern Forest Experiment Station
Room T-10210
U.S. Postal Service Building
701 Loyola Avenue
New Orleans, LA 70113

Forest Products Laboratory
One Gifford Pinchot Drive
Madison, WI 53705

You can also write to Dr. Jerry A. Sesco, the Deputy Chief for Research, located in the Forest Service's Washington Office, at the following address:

USDA Forest Service
PO Box 96090
Washington, DC 20090



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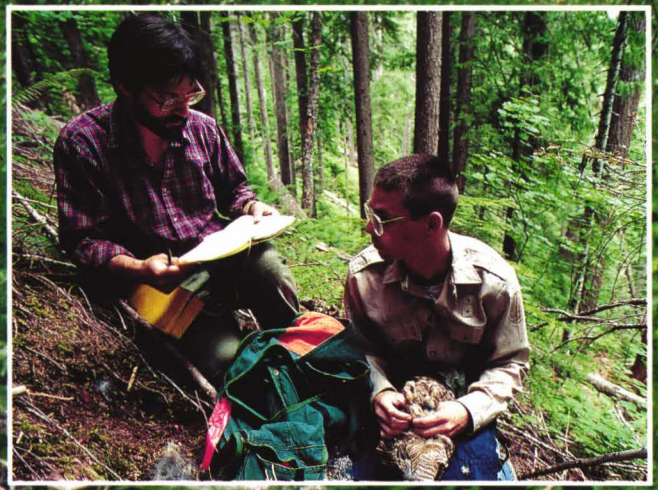

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